Outline of the Ph.D. Work

"Synthesis and Characterization of CdS/Cu_2ZnSnS_4 (CZTS) Heterojunction Thin Films for Solar Cell Applications"

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by

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Introduction:

Every-day updation in life style has rapidly increased the demand for electricity and even more rapidly the conventional sources of energy like fossil fuels, coal etc are exhausting, hence the development of clean energy resources as an alternative to the fossil fuel, has become one of the most important tasks [1-2]. Among wide variety of renewable energy sources, solar energy is the one of the best alternative, suitable for meeting the energy demands of the modern society. In order to promote the use of photovoltaic devices, it is necessary to develop solar cells with low cost, high efficiency, and environment friendly [3, 4]. Thus considering this fact many efforts are being taken to develop device for converting the solar energy into an electrical energy using verity of technologies like thin films. The use of thin film technology starts from Silicon which has now reached to chalcogenide materials namely $CuInSe_2$ (CISe), $Cu(In,Ga)Se_2$ (CIGS), CdTe etc, which are considered to be proved absorber materials [5, 6]. Among these, CIGS and CdTe based thin film solar cells have yielded record conversion efficiencies of ~20.8 and 20.4% respectively, however environmental issues, materials stability, result reproducibility are some of the concerns which have made the researchers to find an alternate source which is abundantly available, non toxic and can result efficiently [7-9], so quaternary Kesterite material Cu_2ZnSnS_4 (CZTS) thin films in heterojunction forms with excellent optoelectronic and physicochemical properties like band gap energy of 1.4-1.5 eV, higher absorption coefficient i.e. 10^4 cm^{-1} are considered [10, 11]. Apart from meeting all required conditions the interface, composition, crystal phase of accompanied window materials and surface morphology plays very vital role in the performance of heterojunction thin films. [12] hence, to overcome this aspects technique like chemical bath deposition (CBD) or modified CBD i.e. chemical ion exchange method would be used. These techniques facilitate the homogenous interface between window and absorber layer, even the elemental composition can also be controlled to some extent by using CBD or ion exchange method. Although literature survey revealed CZTS thin films deposition using enormous techniques like conventional vacuum and non-vacuum methods including RF magnetron sputtering [13], vacuum evaporation [14], pulsed laser deposition [15], e-beam evaporation [16], vapor phase sulfurization [17], spray pyrolysis [18], sol-gel [19], electro and photochemical deposition [20], successive ionic layer adsorption reaction (SILAR) [21] but very few reports are available about use of chemical

bath deposition (CBD) method and even rarely there may be any article explaining use of ion exchange method [22, 23]. Even merits of CBD or ion exchange techniques include stable, adherent, homogeneous, durable, large area deposition techniques and user friendly. Furthermore, the growth of the film can be controlled by optimizing various parameters like deposition time, pH of the solution, bath temperature and by changing the composition of the precursor solution. Even it is hard to find any article mentioning about use of annealing techniques i.e. post deposition treatment on properties of CdS/CZTS heterojunction thin films.

Although some reports explain different techniques and technologies used for increasing the performance of heterojunction thin films solar cell of various compositions but still there are some scopes for studying the properties of heterojunction thin films of CdS/CZTS grown by chemical bath deposition techniques or chemical ion exchange technique over the substrate. The as-grown heterojunction thin films would be studied for physicochemical and opto-electronic properties and thereby solar cell performance will be evaluated.

Objective:

The main objectives is to deposit uniform and adhesive heterojunction thin film of CdS/CZTS by chemical bath deposition or chemical ion exchange method over the substrate surface and study it's structural, compositional, morphological, optical and electrical properties including I-V characterization techniques.

Work plan and methodology:

Synthesis:

Heterojunction thin film of CdS/CZTS will be deposited by using either chemical bath deposition or ion exchange method over the glass and ITO substrate with the Silver contacts. The deposition parameters will be optimized for obtaining good thin films and will be characterized for physicochemical and optoelectronic properties.

Characterization:

Film Thickness:

Film thickness will be measured either by using Gravimetric Weight Difference Method or Spectrophotometric Method.

Structural and Morphology:

The structural and morphological characterization of the synthesized thin film will be using

1. X-ray Diffractogram (XRD),
2. Scanning Electron Microscopy (SEM),
3. Energy Dispersive Analysis by X-ray (EDAX)
4. Transmission Electron Microscopy (TEM),
5. Selected Area Diffraction Pattern (SAD)

Optical Study:

The optical characterization will be performed for the Absorbance, and subsequently for energy band gap calculations using UV-Vis Spectrophotometer and Raman spectra.

Electrical Characterization:

The electrical characterization such as conductivity, Hall-effect will be calculated for confirming the electrical properties.

Solar Cell Characteristics:

I-V characteristics will be studied under the dark and light illumination conditions for studying performance and efficiency of heterojunction thin films deposited using optimized method i.e. either chemical bath deposition method or ion exchange method.

Future Scope of the work:

Now days everyone is scared about the supply of electricity for gadgets of luxurious life on the other hand the environment issues are also increasing the anxiety of common man, hence finding of new sources useful for harnessing the solar energy has become very essential, hence we hope that the finding through the present investigation will add new knowledge to the fundamentals of thin film based solar cell and will open a new dimension for search in heterojunction CdS/CZTS thin films using economically viable, user friendly, techniques like chemical bath deposition or modified chemical bath deposition method.

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